



## Drilling for Success: Intel® Architecture Gives Saudi Aramco an Edge in Handling Rising Tide of Seismic Data

### SOLUTION SUMMARY

#### Challenge

Seismic data processing can make the difference between a successful exploration and one that wastes millions of dollars. With its data volumes doubling every year, the world's leading oil producer/exporter and a top producer of natural gas needed a scalable and cost-effective way to meet its seismic data processing needs.

#### Solution

Saudi Aramco ported one of its mission-critical seismic data processing applications to a cluster of 1,800 Intel® processors. By moving its Prestack Time Migration (PSTM) application from a RISC platform and working with software experts from Intel Corporation to optimize its code for Intel® architecture, Saudi Aramco enjoyed a 33 percent performance boost and deployed a system that cost a fraction of its previous platform.

#### Business value

For Saudi Aramco, faster and more powerful seismic data processing means better decision making, faster time to money and reduced production costs. Using the Intel®-based solution, the company's geophysicists gain a more accurate picture of where the oil lies, increasing the company's success rate for drilling, and reducing the time, money and effort wasted on false starts. The affordability and scalability of the Intel-based solution produce IT savings that will accelerate as the company expands its infrastructure to accommodate rising data processing requirements. Business savings are also anticipated as the faster, more accurate results enable Saudi Aramco to use its drilling equipment and exploration personnel more effectively. Net effect: A positive impact on both the top and bottom line.

#### Systems

900 IBM rack-mounted 1U nodes, growing to 2,000 nodes by January 2003. Each node has two Intel® Pentium® III processors running at 1.4 GHz and 2 GB of memory.

#### Operating system

Red Hat Linux® 7.2

#### Application

Proprietary Prestack Time Migration (PSTM) software

#### Cluster interconnect

100Mb Fast Ethernet

#### Messaging software

OpenMP within nodes; MPI (Message Passing Interface) across the clusters

### Challenge

#### TECHNOLOGY MEETS OIL AND GAS

In the oil and gas industry, it doesn't matter how much liquid gold is locked beneath the earth's surface. If it can't be produced at a reasonable cost, it's worthless. That's why today's oil and gas producers use cutting-edge technology to evaluate buried reservoirs before committing to the costly process of bringing the oil to the surface.

**“By the end of the year, we are planning to have close to 4,000 Intel® CPUs performing Prestack Time Migration.”**

**Mohammad Huwaidi**  
Exploration Systems Analyst  
Saudi Aramco

Founded in 1933, Saudi Aramco is the global petroleum enterprise of the Kingdom of Saudi Arabia. It leads the world in crude oil production and exports, and is a top producer and exporter of natural gas. Saudi Aramco has discovered and oversees about one-quarter of the world's conventional oil

reserves. Since it first found crude oil in commercial quantities in Saudi Arabia's Eastern Province in 1938, the company has discovered about 90 oil and gas fields throughout the Kingdom and in its offshore waters.

More than one-quarter of these discoveries have been made since 1989, a clear sign that new technologies stand to accelerate the unearthing of oil and gas supplies. In 2001, Saudi Aramco celebrated the discovery of a giant oil and gas field near Jufayn, where more than 100 wells now operate.

These discoveries by Saudi Aramco—and similar ones by other oil and gas companies—were made possible by technology. Advances in the development and deployment of this technology have contributed to a much higher drilling success rate and a reduction in the number of dry holes. Better solutions and more affordable computing power mean oil and gas companies can identify and tap new reserves faster, more efficiently, and more profitably than ever before. Chief among these technological developments has been the application of vastly increased computing power to geophysical and geological interpretation. Recently, Saudi Aramco directed better computing power at the task of seismic data processing—one of its most mission-critical applications.

#### **GUSHING DATA**

When Saudi Aramco explores new oil and gas reserves, it collects vast amounts of seismic data (16 billion traces per year and growing) in either two or three dimensions. Sound waves are sent through the ground, and as they bounce back, they begin to paint a picture of what is below the earth's surface.

Unfortunately, not all the seismic data Saudi Aramco collects is useful. The sound waves also include high levels of noise from extraneous sources, including those on the surface, as well as reverberations caused by sound waves bouncing around. To get a clear picture of possible oil and gas deposits, the seismic data must be cleaned

up to remove noise and enhance the image. One of the leading ways to achieve this is through a method called Prestack Time Migration (PSTM).

PSTM is a set of compute-intensive algorithms that takes each trace, enhances it, and assembles it into a usable image of the oil or gas deposit. Saudi Aramco employs Kirchhoff PSTM, which executes up to 5 million instructions per data point. While the quality of Kirchhoff PSTM is excellent, it can also be costly, so performing its PSTM in a cost-efficient way has become important to Saudi Aramco.

Newer, more significant and sophisticated methods of collecting seismic data have meant the amount of data Saudi Aramco must process each year is *doubling*. Therefore, the company must make sure its PSTM application can grow quickly and efficiently to meet demand. Its technology absolutely cannot lag behind. Newer and better data that is processed quickly and thoroughly is what helps keep Saudi Aramco in its leadership position.

“This is a mission-critical application,” says Mohammad Huwaidi, an exploration systems analyst at Saudi Aramco. “It does some of the most important work in our business. Some of the old ways we ran our PSTM just didn't work well or didn't have enough power. So we made a change.”

#### **Solution**

##### **CHOOSING INTEL® ARCHITECTURE**

Huwaidi describes the evolution of Saudi Aramco's PSTM computing platform as a series of leading-edge technology choices.

“We tried to do some PSTM on a supercomputer, but it was not economical to run,” he says. “Then we developed the parallel code on symmetric multiprocessing SGI systems and eventually moved to a distributed, high-performance clustered computing system.”

Saudi Aramco's RISC system employed 512 64-bit processors to perform the PSTM chores. It served Saudi Aramco well, but according to Huwaidi, the company wanted to move to a current leading-edge technology that would be cheaper to deploy and more expandable to meet Saudi Aramco's growing needs. Saudi Aramco therefore contacted IBM to explore the possibility of running its seismic data processing solution on Intel® processor-based systems. The result was a cluster of 128 Intel® Pentium® III processors arrayed in a series of racks. And as Saudi Aramco validated Intel® architecture's performance and reliability, it grew its cluster to

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**Gernot Hoyler**  
Technical Marketing Engineer  
Intel Munich

1,800 CPUs by the middle of 2002. The superior scalability of Intel®-based systems ensures that Saudi Aramco will be able to grow its PSTM cluster to meet its seismic data processing needs.

“By the end of the year, we are planning to have close to 4,000 Intel® CPUs performing Prestack Time Migration,” says Huwaidi.

#### **INTEL SUPPLIES EXPERTISE**

When Saudi Aramco decided to deploy Intel architecture-based clusters, it needed additional expertise to help port and optimize its PSTM code. Software experts from Intel in Germany flew in for roughly two days of intensive programming to launch the PSTM application on its new platform.

With the help of Intel, Saudi Aramco tuned the PSTM code on the Intel Pentium III processor-based architecture. The group used the Intel® Fortran Compiler for Linux® 6.0 and Intel® VTune™ Performance Analyzer to identify parts of the code that would benefit from further optimization.

“We were able to get the PSTM application to run at least 33 percent faster than it had before,” explains Gernot Hoyler, a technical marketing engineer at Intel in Munich, who worked with Saudi Aramco to tune and optimize its PSTM code. “With additional tuning, we hope to boost performance by 50 percent.”

Huwaidi says Saudi Aramco was particularly pleased with the effort Intel put into getting the most out of its PSTM application. “Intel was very responsive to our needs,” he explains. “The optimization they did to our code gave us a significant increase in performance.”

Today, Saudi Aramco’s PSTM application runs on several clusters with a total of 900 rack-mounted nodes, each with two Intel Pentium III processors running at 1.4 GHz and 2 GB of memory. The company chose Red Hat Linux® as its operating system due to its popularity in the seismic industry.

Because the PSTM application is compute-intensive rather than communications-intensive, Saudi Aramco employs 100Mb Fast Ethernet across its clusters. For other clustered solutions that rely more heavily on communications across the cluster, the company uses even faster Quadrics interconnects.

For the messaging software that passes data around the cluster, Saudi Aramco employs two solutions. Within each of the 900 nodes, the company uses OpenMP, a portable, scalable, industry-standard API that supports multi-platform, shared-memory parallel programming in C/C++ and Fortran on all architectures. For messaging among nodes, Saudi Aramco uses the Message Passing Interface (MPI) standard. “It’s extremely fast and it’s a de facto standard,” says Huwaidi.

#### **HIGH PERFORMANCE THAT’S ALSO COST EFFICIENT**

Having built a high performance computing cluster from Intel® processors, Saudi Aramco now enjoys an important by-product of its technology migration: The Intel-based systems are far more cost-efficient than the company’s previous PSTM systems. In fact, Saudi Aramco says it now gets better performance for one-eighth the cost of competitive solutions. In the oil and gas industry, this kind of cost-efficiency goes a long way toward making exploration and discovery efforts more profitable.

“In the end, we built the fastest yet least expensive PSTM system,” says Huwaidi. “Our ability to rapidly and inexpensively add computing power to our cluster is a major benefit of the Intel® platform.”

Saudi Aramco’s choice of Intel architecture expands the company’s ability to keep pace with its rapidly growing processing requirements. Not only can Saudi Aramco grow the cluster by adding processors whenever it needs more power, it can also take advantage of the steady performance hikes delivered by successive generations of Intel processors. For example, the Intel® Xeon™ processor is available at core speeds of up to 2.80 GHz and rising. Combining these high clock speeds with the new Intel® NetBurst™ microarchitecture and Hyper-Threading Technology, the processor delivers advanced performance and scalability for a broad range of business and technical computing applications. The Intel Xeon processor is manufactured on Intel’s sophisticated 0.13 micron technology, making it especially well suited to the power and density requirements of high performance clusters.

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Saudi Aramco is also looking to deploy Intel architecture-based clusters to run other parts of its petroleum process. One application provides 3-D and 4-D simulations to help geologists envision the size and shape of reservoirs as they change over time. By deploying additional Intel-based systems throughout its enterprise, Saudi Aramco will benefit from open, standards-based technologies that will make it easier than ever to build and rebuild its infrastructure as times and technologies change.

Moving its PSTM application to Intel architecture was the beginning of a strategic shift for Saudi Aramco. The important characteristics of Intel processors—fast, stable, flexible, affordable—all coincide perfectly with Saudi Aramco's requirements for growing the company and delivering the best products and services to its customers.

If you have a specific question on how Intel engages in such projects, please contact the Intel Energy Competency Center in Abu Dhabi.

## LESSONS LEARNED

- **Intel® architecture-based clusters deliver.** Saudi Aramco ported its parallel Prestack Time Migration application from a 64-bit, RISC-based cluster to a 32-bit Intel® Pentium® III processor-based cluster and found it achieved the same or better performance on the Intel architecture platform as it did on the RISC system. And with its faster clock speeds, 0.13 micron process technology and Hyper-Threading Technology, the Intel® Xeon™ processor should give Saudi Aramco superb performance characteristics as it expands its use of Intel architecture-based high performance computing clusters.
- **Intel® software enabling can help ensure your success.** Software experts from Intel helped Saudi Aramco optimize its ported PSTM code. As a result, the software ran 33 percent faster than it had before—a substantial improvement on the same Intel-based system.
- **Intel architecture enables rapid growth.** When Saudi Aramco built its first Intel architecture-based cluster, it consisted of 128 CPUs. Just seven months later, the company had 1,800 clustered CPUs supporting PSTM. By the end of 2002, Saudi Aramco expects to have close to 4,000 Intel processors running its PSTM application. The ability to easily scale its infrastructure—and take advantage of each new generation of processor performance enhancements—is an important part of the company's strategy for deriving and analyzing crucial seismic data.
- **Superior price/performance means a significant advantage.** In the oil and gas industry, companies need to know they can produce energy resources at a reasonable cost or they might as well stop drilling. Migrating its PSTM application to a platform that provides dramatically improved performance at significantly less cost than other solutions takes Saudi Aramco a long way toward increasing its chances of profitable exploration.

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